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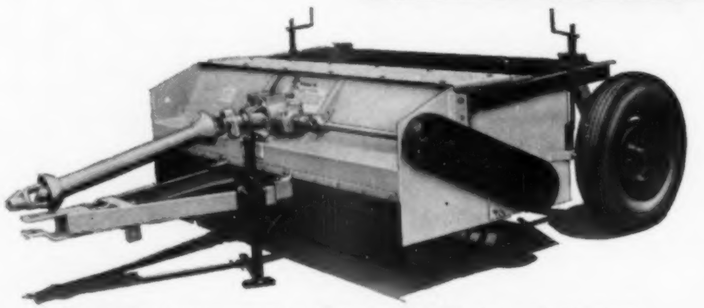

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THE EFFECT OF SEVERAL COMPOUNDS ON POST-HARVEST DECAY OF POTATOES[1]

F. B. Cates and L. O. Van Blaricom

The problems confronting South Carolina growers in harvesting and preparing Irish potatoes for shipment are similar to those encountered by other growers in the Southeast. One of the more serious problems with which growers have to contend each season is decay of potatoes occurring between shipping point and retail outlet.

The practice of applying a compound as a post-harvest dip to reduce decay is common in the citrus industry. The usefulness of antibiotics in prolonging shelf-life of packaged endive, chickory, escarole, and lettuce has been demonstrated by Carroll, Benedict, and Wrenshall (3). Koch and Carroll (4) have prolonged the shelf-life of cauliflower, lima beans, and spinach with oxytetracycline used as a dip. Antibiotics were successfully used by Bonde (1) to control Irish potato seed piece decay caused by *Erwinia atroseptica* and *Pseudomonas florescens*.

These findings suggest the use of a compound on potatoes to reduce post-harvest decay. Solutions could be applied with the wash water or as a spray following the washing operation. Based upon these postulations, an investigation was conducted to evaluate the effectiveness of several compounds in reducing post-harvest decay.

Materials and Methods

For purposes of clarity, experiments have been classified into field and laboratory tests. Field tests include those experiments conducted with whole potatoes. Laboratory test refers to the experiment performed in the laboratory on plugs of potatoes.

Field Tests, 1959

The effectiveness of 11 compounds and one combination of compounds in reducing post-harvest decay was studied. New-crop Sebago potatoes were bruised individually. Samples were dipped in an extract of rotted potatoes and allowed to dry. After drying they were dipped momentarily in one of the treating solutions, bagged in small burlap bags, and stored at room temperature for 7 days. Samples were then examined for evidence of rot and phytotoxicity.

Both treated and check samples failed to decay. Samples treated with sodium o-phenylphenate showed severe phytotoxicity. None of the remaining treatments caused phytotoxicity.

Laboratory Test

With the exception of sodium o-phenylphenate, the compounds and concentrations used in 1959 field tests were used in the laboratory test (Table 1). Whole potatoes were placed in a water bath at 115°F. for 1

[1]Accepted for publication October 14, 1960. Technical contribution No. 342, Department of Horticulture, South Carolina Agricultural Experiment Station, Clemson, South Carolina.

TABLE 1.—*Decay of potato plugs treated with various compounds and inoculated with Erwina cartovora.*

Treatment	Concentration	Soft rot development expressed as per cent weight loss[1]
	ppm.	
Agrimycin (100)[2]	200	6.9
	100	12.7
	50	77.2
Agrimycin (100)[2] with captan	200 1196	5.9
	100 598	20.6
	50 299	59.8
Candicidin	200	100.0
	100	100.0
	50	100.0
Captan	1196	85.0
	598	96.7
	299	99.4
Chloride (Calcium hypochlorite)	200	98.6
	100	98.0
	50	100.0
Chlortetracycline	1000	15.4
	500	11.1
	250	8.7
Dehydroacetic acid	4000	41.9
	2000	26.6
	1000	50.1
Mycostatin[3]	1500	100.0
	750	100.0
	375	100.0
Sodium Omadine	1500	24.6
	750	29.8
	375	88.1
Tyrocidine hypochloride	200	99.1
	100	100.0
	50	99.7
Check 1[4]		100.0
Check 2[5]		1.2
L.S.D. .05		4.6
L.S.D. .01		6.2

[1] Average of three replications.
[2] An antibiotic formulation containing 15% streptomycin activity, 1.5% oxytetracycline activity, a wetting agent, and an acidifying agent, in an inert diluent.
[3] Chemical 1484. Trade mark of Olin Mathieson Chemical Corporation.
[4] Inoculated. Average of six replications.
[5] Non-inoculated. Average of three replications.

hour. The water bath, according to Neilson (5), simulates solar heating and predisposes the potato to bacterial invasion. Following the water bath, the tubers were cooled in tap water and the surface sterilized by dipping in ethyl alcohol for 5 minutes. Cores were removed from the center of the potatoes with a 19 mm cork borer and cut into ⅜ inch thick plugs. The plugs were weighed, dipped for 30 seconds in one of the treating solutions, transferred to Petri dishes containing 3 ml of distilled water and inoculated with a pure culture of *Erwinia carotovora*. Check treatments were dipped in distilled water. Forty-eight hours following inoculation, the plugs were removed, washed in tap water to remove the decayed tissue, blotted dry and weighed. Decay was reported as the per cent weight lost.

Agrimycin 100 at 100 and 200 ppm was quite effective in controlling decay (Table 1). This is in agreement with results reported by Bonde (1). Lower concentrations of Agrimycin gave less control (Fig. 1).

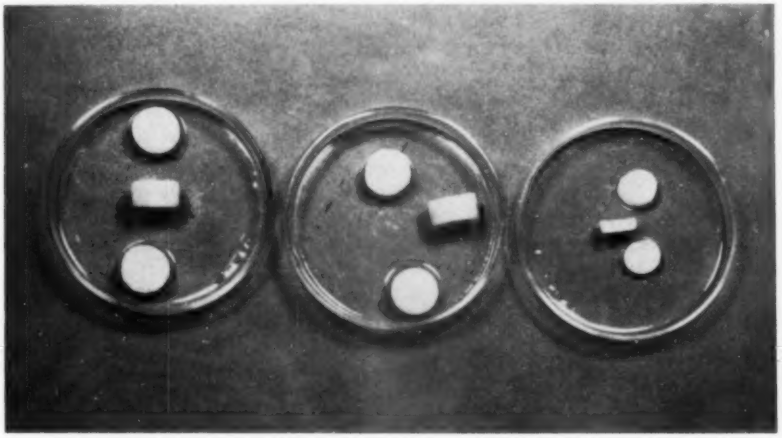

FIG. 1.—Deterioration of potato plugs dipped in Agrimycin 100 and inoculated with *Erwinia carotovora*. Left, 200 ppm; Center, 100 ppm; Right, 50 ppm.

Chlortetracycline solutions at 250, 500, and 1000 ppm effectively controlled decay. However, decay increased as the concentration was increased. Also, plugs treated at 1000 ppm were considerably darker than those treated at lower concentrations (Fig. 2). The remaining compounds were only partially effective or completely ineffective in reducing decay.

Field Tests, 1960

Agrimycin 100, Agrimycin 100 plus captan, chlortetracycline, and chlortetracycline plus captan were used in a field test at Clemson College. Size B, new-crop, Sebago potatoes were individually bruised, dipped for 15 seconds in one of the treating solutions, allowed to dry, and sprayed with an extract prepared from rotted potatoes. Samples were then placed in small burlap bags and stored under wet burlap and a plastic sheet on a greenhouse bench. After 4 days the samples were examined for decay.

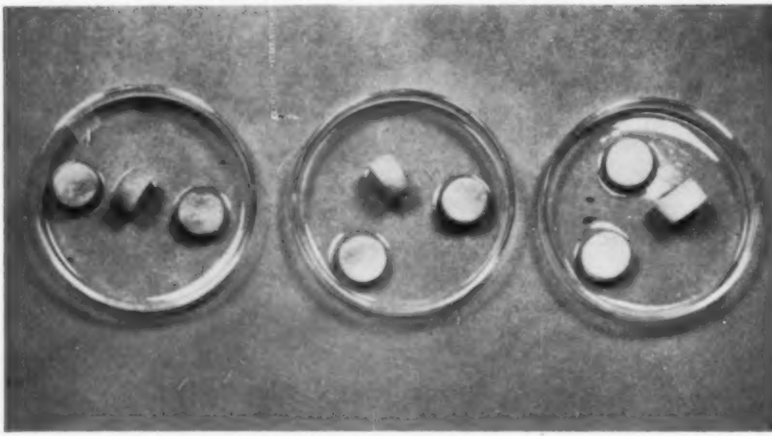

FIG. 2.—Deterioration of potato plugs dipped in chlortetracycline and inoculated with *Erwinia carotovora*. Left, 1000 ppm; Center, 500 ppm; Right, 250 ppm.

The results of this experiment are presented graphically in Fig. 3. Solutions containing Agrimycin 100 did not reduce decay and are therefore not included on the graph. The addition of captan to chlortetracycline greatly reduced the stimulatory effect on rot exhibited by chlortetracycline alone.

The results of this experiment suggested that captan alone might control decay. Consequently, a similar experiment was performed to test the effectiveness of five concentrations of captan on decay.

A significant reduction in decay was obtained with each concentration (Table 2). The per cent of decayed potatoes in uninoculated check samples was considerably higher than in uninoculated check samples in the previous experiment. This was probably due to a layer of water approximately ¼ inch deep which had collected on the bench under all the sample bags. The excess water resulted from over-watering the large burlap bags which were used to cover the samples in order to maintain a high relative humidity. The water caused the potatoes in the bottom of each sample bag to decay. However, 95% of the potatoes in the inoculated check samples rotted as compared with 54.8% in the samples which had been treated with captan at the lowest concentration.

Discussion and Conclusions

The effectiveness of 11 compounds and one combination of compounds to control post-harvest decay has been evaluated.

The thin periderm of potatoes is readily injured by concentrations of sodium o-phenylphenate at 1000 ppm and higher. This injury allows the entry of pathogens and a consequent increase in decay follows. It may be concluded that sodium o-phenylphenate treatments at 1000 ppm or above are not suitable for use on potatoes.

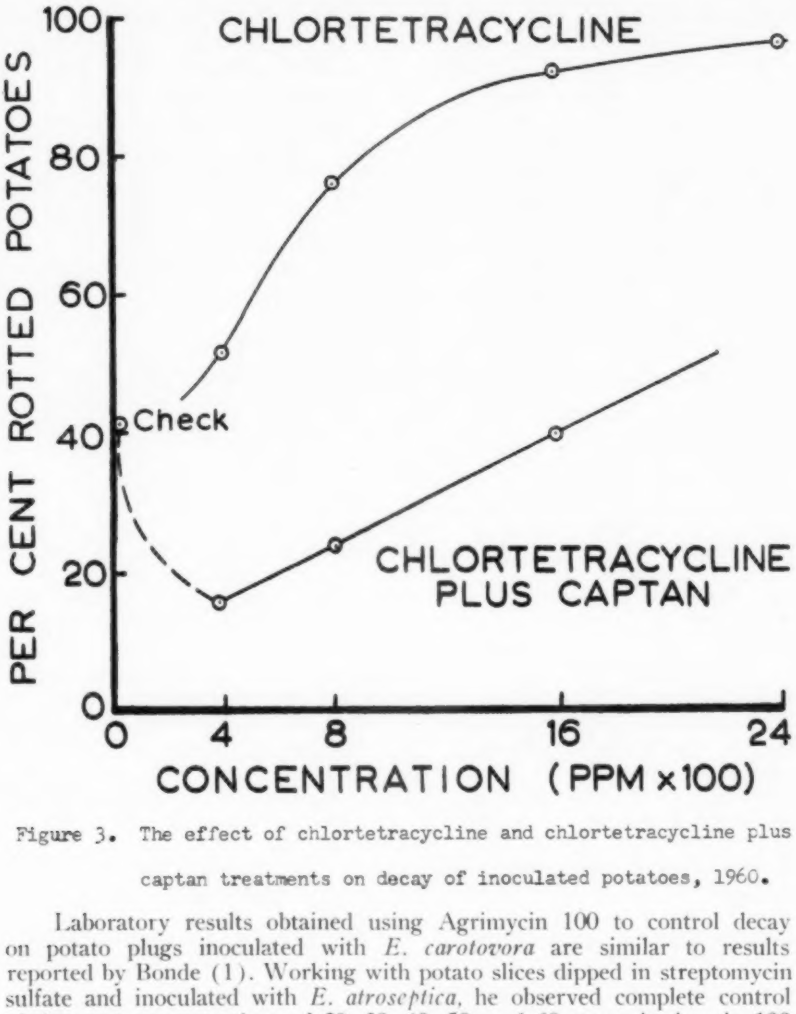

Figure 3. The effect of chlortetracycline and chlortetracycline plus captan treatments on decay of inoculated potatoes, 1960.

Laboratory results obtained using Agrimycin 100 to control decay on potato plugs inoculated with *E. carotovora* are similar to results reported by Bonde (1). Working with potato slices dipped in streptomycin sulfate and inoculated with *E. atroseptica*, he observed complete control of decay at concentrations of 20, 30, 40, 50, and 60 ppm. Agrimycin 100 did not significantly reduce decay in field experiments conducted at Clemson College. These results would at first appear contradictory to the findings of Bonde and Malcolmson (2), and Robinson and Hurst (6), who have reported control of potato seed piece decay with dips of Agrimycin 100. However, these workers used potatoes that were inoculated with a pure culture of *E. atroseptica*, whereas, the inoculum used by the authors was an extract of rotted potatoes which contained many types of bacteria and fungi. Also, the high humidity caused by the covering of wet burlap and plastic sheet produced a condition near optimum for decay. Under less

TABLE 2.—*The effect of captan on decay of inoculated potatoes, 1960.*

Concentration	Rotted potatoes[1]
ppm.	pct.
3200	59.4
2400	62.7
1600	60.4
800	66.0
400	54.8
Check 1[2]	95.0
Check 2[3]	54.8
L.S.D. .05	11.6
L.S.D. .01	16.6

[1]Average of three replications.
[2]Inoculated. Average of six replications.
[3]Uninoculated. Average of three replications.

severe storage conditions, as may have been encountered in the soil, Agrimycin 100 might be expected to reduce decay caused by *E. atroseptica* or its synonym, *E. carotovora*.

Chlortetracycline effectively controlled decay on inoculated potato plugs. Decay of potato plugs increased as the concentration of chlortetracycline was increased (Table 1). However, each concentration was highly significant in reducing decay. A similar relationship between chlortetracycline and rot development was noted in the 1960 field experiment at Clemson College (Fig. 3). Chlortetracycline solutions at 400 ppm increased decay above the inoculated check treatments. Decay was proportionately increased by concentrations of 800, 1600, and 2400 ppm. The results of these two experiments are similar in that decay was increased as the concentrations of chlortetracycline were increased. They are dissimilar in that, in the field experiment, potatoes treated with chlortetracycline rotted significantly more than inoculated check treatments. In the laboratory experiment, significant control of decay was obtained. The authors submit the following postulation to explain this dissimilarity: The phytotoxicity of chlortetracycline increases as the concentration increases. Consequently, as the concentration is increased, more injury to the periderm occurs. This renders the potato more susceptible to invasion by pathogens not controlled by chlortetracycline. In the experiment with potato plugs only one pathogen, *E. cartovora*, was involved. Since chlortetracycline is bactericidal against this organism, the phytotoxic effect was not amplified by bacterial decay.

The addition of captan to chlortetracycline reduced the stimulatory effect on decay caused by chlortetracycline alone. The postulation offered previously to explain the phytotoxic and bacterial effect of chlortetracycline

appears to be adequate to partially explain this phenomenon. At the lower concentrations the phytotoxic effect of chlortetracycline was only slightly injurious to the periderm. The addition of captan retarded the development of pathogens. As the concentration of chlortetracycline and captan was increased, periderm injury and decay increased. The added captan retarded but did not completely control these pathogens.

Results with the use of captan alone, at concentrations of 400, 800, 1600, 2400, and 3200 ppm, were highly significant in controlling decay. This substantiates the results obtained previously when captan alone was added to chlortetracycline. Significance in rot control was obtained with all concentrations. This suggests that captan might be effective when used as a dip with commercial potato washing machines.

Literature Cited

1. Bonde, Reiner. 1953. Preliminary studies in the control of bacterial decay of the potato with antibioitcs. Am. Potato J. 30: 143-147.
2. Bonde Reiner and J. F. Malcolmson. 1956. Studies in the treatment of potato seed pieces with antibiotic substances in relation to bacterial and fungous decay Plant Disease Reptr. 40: 615-619.
3. Carroll, V. J., R. A. Benedict, and C. L. Wrenshall. 1957. Delaying vegetable spoilage with antibiotics. Food Tech. 11: 490-493.
4. Koch, G. and V. J. Carroll. 1956-1957. Prevention of post-harvest decay with antibiotics. Antibiotics Ann. 1010-1014.
5. Neilson, L. W. 1946. Solar heat in relation to bacterial soft rot of early Irish potatoes. Am. Potato J. 23: 41-57.
6. Robinson, D. B. and R. R. Hurst. 1956. Control of potato blackleg with antibiotics, Am. Potato J. 33: 56-59.

SOME FACTORS INFLUENCING THE CULINARY QUALITY OF SOUTHERN- AND NORTHERN-GROWN IRISH POTATOES. I. CHEMICAL COMPOSITION[1]

EARL P. BARRIOS, D. W. NEWSOM, AND J. C. MILLER[2]

The culinary quality of the Irish potato (*Solanum tuberosum* L.) has been a frequent subject for research. Results, as interpreted, have often been contradictory because objective and uniform standards for judging quality have not been developed, and knowledge of the changes which occur during cooking has been elusive.

The present study was designed to correlate possible variations in mealiness with the chemical composition of southern-grown Irish potatoes, and tubers of the same varieties produced at a northern location. Since most southern-grown potatoes are less mealy than northern-grown tubers, knowledge of the factors related to mealiness could prove helpful in the breeding, selection, and culture of varieties possessing higher mealiness when grown under southern conditions.

Surveys (3, 4, 6, 7) have shown that housewives and food processors prefer a mealy, white-fleshed Irish potato for baking and for chip manufacture. Tubers which are less mealy have been widely used for boiling or salad purposes. However, mealiness is the Irish potato culinary quality preferred by most authorities in the United States.

Much of the research on potato-tuber quality has been directed towards determining the factors related to mealiness, which are generally grouped into those of a physical and those of a chemical nature. No precise method of predicting the quality of the cooked product has yet been devised although specific gravity of the raw tubers has generally been considered the most practical index. A positive correlation between the specific gravity and dry-matter content of tubers has been demonstrated. Workers and food processors have used specific gravity as a measure of the dry-matter content and as an indication of quality in Irish potatoes. High specific gravity usually is associated with high dry-matter content and quality.

However, exceptions to a correlation between specific gravity and mealiness have been reported (6, 8, 13, 20). Interpretation of results has varied considerably, but often no positive correlation existed between specific gravity and mealiness. Hawkins (6) reported that specific gravity did not correctly indicate the starch content nor, by inference, the mealiness of potatoes. Kirkpatrick (8) found no significant relationship between specific gravity and mealiness in boiled, baked, or mashed potatoes.

Schark (13) concluded that some factor other than specific gravity influenced the evaluation of mealiness in tubers tested by a taste panel. This opinion was based on the fact that tubers of identical specific gravity differed in mealiness when assessed by the judges. According to Whittenberger (20) the accuracy of specific gravity for indicating starch content and mealiness varied with storage conditions, least accuracy being with tubers stored at low (35° F.) temperatures.

[1]Accepted for publication November 7, 1960.

[2]Assistant Professor, Professor, and Head, respectively, Department of Horticulture, Louisiana State University, Baton Rouge, Louisiana.

Research (1, 2, 18) has indicated that a correlation existed between the percentage of starch and dry matter in raw tubers and mealiness ratings of cooked tubers, but the exact nature of the relationship has not been determined. Starch content was correlated with specific gravity, but in some cases tubers of different varieties, having identical specific gravity, did not necessarily have the same starch content.

Unrau and Nylund (19) reported that although a positive correlation existed between mealiness and starch content, the low mealiness scores of some tubers with high specific gravity could not be explained by starch content alone. Starch from low-specific gravity tubers, however, contained less amylose. Because of differences in the chemical composition of potato starch, high concentrations of amylose could confer greater mealiness, whereas high amylopectin content caused waxiness. Their data on the relationship between amylose content and mealiness ratings of tubers, as assessed by taste panels, seemed to agree with these suppositions. Potato tubers showing the highest mealiness scores by taste test also contained the highest percentage of amylose.

Materials and Methods

Tubers of four Irish potato varieties, Red LaSoda, Sebago, White Rose, and Russet Burbank, were planted and harvested at a northern and southern location (Starks Farms, Rhinelander, Wisconsin, and Ben Hur Farm, Baton Rouge, Louisiana) for this research. Spring and fall crops were grown at Baton Rouge. Potatoes of all varieties were planted on the same date at each location. Four harvests of both spring and fall crops were made at Baton Rouge; the first at the normal harvest period. The 1959 Louisiana fall crop was destroyed by an early frost.

Southern-grown potatoes were placed in 70° F. storage immediately following harvest. Northern samples were shipped to Baton Rouge and stored at 70°. All lots remained in this storage for one month before chemical analyses were made. The effects of variety, growing season, and location on tuber quality were evaluated.

Specific gravity and dry matter content were determined by the potato hydrometer (15).

Organoleptic tests were made by eight staff members who served on the taste panel throughout this research. Panel members were asked to rank the tuber samples in an ordinal arrangement of 0 to 4 (mealiest sample = 4; waxiest sample = 0). The criteria used to determine mealiness and waxiness were as described by Sweetman (18). Tubers were baked and served warm, without the addition of table salt or other seasoning.

The same tubers used in the specific gravity and mealiness ratings provided material for the determination of total starch and amylose content. One half of the unpeeled tuber was cooked for organoleptic evaluations and the remaining half was used for chemical determinations. Samples for analysis were obtained with a 9/16 inch cork borer, using one longitudinal and one cross-sectional core. This method allowed a more representative sample by modifying the variations of constituents in different areas of the tuber. The core samples were then used for the chemical measurements. Four replications were used in all chemical determinations.

Total starch determinations were based on the method of Nielsen (11), with some modifications (12). The fresh sample was ground in a Waring Blendor, the starch extracted with 4.0 to 4.8 molar perchloric acid, and the dissolved starch estimated by photoelectric colorimeter readings of the blue color produced with iodine. The use of a K55 red filter in the colorimeter for the readings has been reported (11) to reduce considerably the error produced by dextrins.

The percentage of starch was calculated from a standard curve prepared from the colorimeter readings of a known range of starch concentration, based on raw starch extracted from potato tubers.

Amylose and amylopectin percentages were estimated colorimetrically according to the method of Halick and Keneaster (5). The procedure was modified for potatoes and was based on the color reaction of amylose with iodine, which has been reported to indicate the amylose content of various starches (9).

A standard curve for determination of amylose and amylopectin percentages was obtained by the procedure outlined for this method.

Experimental Results

Marked variations in specific gravity existed between tubers of the four varieties. Specific gravity was also influenced by location, growing season, and date of harvest (Tables 1 and 2 and Fig. 1).

Table 1.—*The effect of variety, season, and location on the specific gravity, mealiness, starch and amylose content of potato tubers.*

Variety	Specific gravity	Mealiness rating*	% Total starch	% Amylse
	La. Spring Crops (1958 and 1959)			
Red LaSoda	1.052	1.27	12.5	6.4
Sebago	1.053	1.43	12.9	7.8
White Rose	1.055	1.74	13.3	8.2
Russet Burbank	1.064	2.53	15.2	9.2
	La. Fall Crop (1958)			
Red LaSoda	1.068	2.00	14.8	7.5
Sebago	1.069	1.25	15.5	11.8
White Rose	1.067	1.75	15.7	8.4
Russet Burbank	1.070	2.65	17.5	10.0
	Northern Crops (1957 and 1958)			
Red LaSoda	1.070	1.02	13.2	10.0
Sebago	1.074	1.40	13.4	11.8
White Rose	1.073	1.60	13.9	12.8
Russet Burbank	1.091	2.77	18.9	18.7
	Av. of All Crop Seasons			
Red LaSoda	1.063	1.43	13.5	8.0
Sebago	1.065	1.36	13.9	10.5
White Rose	1.065	1.70	14.3	9.8
Russet Burbank	1.075	2.65	17.2	12.6

**Mealiness scale* — 0 = Waxy, 1 = Sl. waxy, 2 = Sl. mealy, 3 = Mealy, 4 = V. mealy

TABLE 2.—*The effect of variety, season, and harvest date on the specific gravity, mealiness, starch and amylose content of potato tubers.*

Variety	Harvest date**	La. Spring Grown Crops (1958 and 1959)				La. Fall Grown Crop (1958)			
		Specific gravity	Mealiness rating*	% Total starch	% Amylose	Specific gravity	Mealiness rating*	% Total starch	% Amylose
Red LaSoda	1	1.055	1.71	13.0	8.0	1.062	2.00	13.5	4.8
	2	1.057	1.00	12.6	7.6	1.067	1.80	14.8	8.4
	3	1.048	..	..	5.2	1.070	..	..	8.8
	4	1.048	1.10	12.0	4.6	1.073	2.20	16.1	7.8
	Average	1.052	1.27	12.5	6.4	1.068	2.00	14.8	7.6
Sebago	1	1.054	1.86	12.0	8.7	1.068	1.25	14.1	10.2
	2	1.057	1.00	13.6	9.2	1.071	1.00	15.5	14.9
	3	1.050	..	..	6.4	1.072	..	..	13.2
	4	1.050	1.43	13.0	6.7	1.065	1.50	16.9	8.8
	Average	1.053	1.43	12.9	7.8	1.069	1.25	15.5	11.8
White Rose	1	1.055	2.00	13.7	8.6	1.058	1.75	14.3	6.0
	2	1.055	1.57	14.1	9.0	1.075	1.50	15.7	10.5
	3	1.056	..	..	7.6	1.074	..	..	9.8
	4	1.055	1.65	12.0	7.4	1.061	2.00	17.1	7.3
	Average	1.055	1.74	13.3	8.2	1.067	1.75	15.7	8.4
Russet Burbank	1	1.065	3.14	16.2	9.8	1.064	2.65	16.8	6.9
	2	1.067	1.86	14.9	10.0	1.072	2.00	17.5	11.5
	3	1.060	..	..	7.4	1.071	..	..	10.4
	4	1.063	2.57	14.5	9.5	1.071	3.30	18.2	11.2
	Average	1.064	2.53	15.2	9.2	1.070	2.65	17.5	10.0

(Spring)	Harvest dates**	(Fall)
May 30	—1—	Nov. 12
June 12	—2—	Nov. 24
June 26	—3—	Dec. 3
July 10	—4—	Dec. 12

**Mealiness rating:* 0 = Waxy
1 = Sl. waxy
2 = Sl. mealy
3 = Mealy
4 = V. mealy

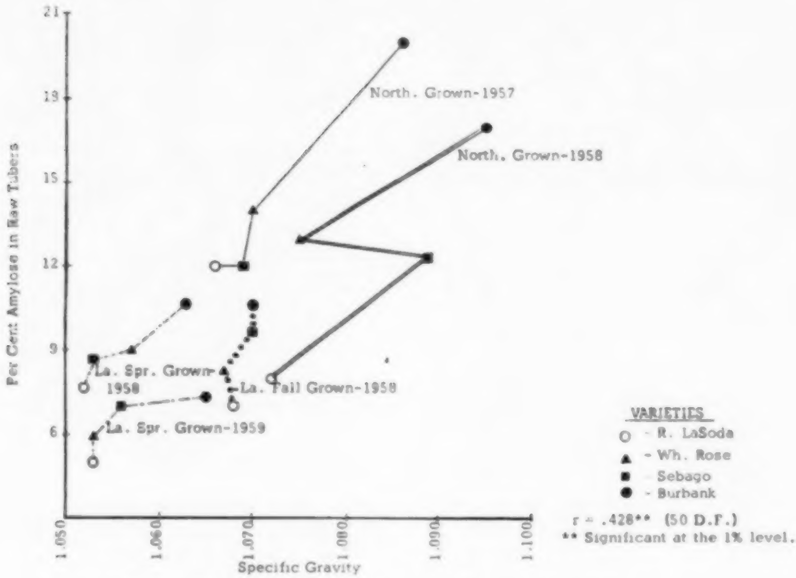

Figure 1. The effect of variety, location, and season on specific gravity and amylose content of potato tubers.

Specific gravity of tubers grown at the northern location was higher than that of corresponding varieties grown at the southern location (Table 1). Specific gravity of tubers produced in the fall at Baton Rouge was higher than that of corresponding varieties grown in the spring at that location.

Russet Burbank tubers were highest in specific gravity, whereas those of the Red LaSoda variety had the lowest specific gravity. White Rose and Sebago potatoes were at an intermediate specific gravity level.

In general, the specific gravity of potatoes produced in the spring under Louisiana conditions decreased as harvest dates were extended (Table 2.) However, the trend was somewhat reversed in fall potatoes grown at Baton Rouge.

There was a high degree of correlation (r = .613) between specific gravity and per cent total starch. Tubers of the Russet Burbank variety contained the highest percentage of total starch in all cases, while Red LaSoda had lowest total starch.

Cooked tubers varied in mealiness ratings with varieties, location grown, and harvest season.

Russet Burbank potatoes were of highest mealiness in all cases. Red LaSoda tubers were lowest in mealiness except for the Louisiana fall crop of 1958.

Taste panel ratings (Table 2) pointed out that the mealiness of tubers grown during the spring in Louisiana decreased with successive harvest dates. The reverse occurred in fall crop harvests at that location.

A comparison of mealiness ratings and specific gravity readings of potatoes grown at the southern location during the spring showed a highly significant relationship ($r = .720$). No correlation between these factors was found in tubers from the other locations or crop seasons .

Mealiness ratings and the total starch content of tubers were significantly related ($r = .597$). Potatoes of the Russet Burbank variety were highest in mealiness ratings and total starch content while those of Red La Soda were lowest.

Varietal differences in total starch content occurred among the four varieties regardless of location or season (Table 1).

Potatoes from the fall crop in Louisiana averaged highest in per cent total starch (Table 1). Those grown at the Wisconsin location ranked next highest, and spring crop tubers at the southern location were lowest in per cent total starch.

The per cent total starch in tubers of all varieties (Table 2) decreased as harvest was delayed in the Louisiana spring crops. Delay of harvest in the fall at this location caused an increased starch content of tubers.

There was a highly significant relationship between per cent total starch and per cent amylose in raw tubers of all varieties ($r = .769$) regardless of location grown or season harvested.

Variety, location, and season of harvest influenced the amylose content of raw tubers. Tubers grown at the Wisconsin location (Table 1) averaged highest in per cent amylose. Louisiana fall-grown potatoes contained the next highest amount of amylose, and those produced in the spring at this location were lowest in amylose. The per cent amylose in tubers of all varieties grown during the spring at Baton Rouge decreased as harvest was delayed. An increased percentage of amylose was found in tubers from the fall crop at that location when the harvest date was delayed (Table 2).

Russet Burbank potatoes (Fig. 1) contained the highest percentage of amylose under all conditions, whereas those of Red LaSoda had the lowest per cent amylose. The amount of amylose in tubers from the southern-grown spring and fall crops of 1958 varied significantly between varieties. Harvest date had a highly significant effect on amylose content. There was also a significant interaction between varieties and harvest dates.

A correlation ($r = .424$) existed between amylose and mealiness ratings of tubers from all crops .

Fig. 1 shows a highly significant relationship between per cent amylose and the specific gravity of the tubers.

Discussion

Differences in specific gravity of tubers reported herein generally agree with other research (8, 14, 16, 17) and indicate that specific gravity is of value as a measure of potato culinary quality. However, it is important to note that associations between specific gravity and mealiness ratings of tubers fluctuated, except at the varietal extremes of Russet Burbank and Red LaSoda. There was no consistency in the mealiness ratings of Sebago and White Rose potatoes, nor in their specific gravity.

A correlation between these two factors was found in Louisiana spring-grown tubers, but none existed in the fall-crop potatoes in Louisiana, nor in tubers produced at Wisconsin.

The higher specific gravity of tubers grown at the northern location was expected. Relatively high temperatures in Louisiana during the spring season are not conducive to accumulation of dry matter in potato tubers. However, the specific gravity and mealiness of southern fall-grown tubers compared favorably with the Wisconsin crops. This fact shows that varieties which would mature in the short daylengths of Louisiana fall conditions might be of value to potato growers and processors.

Comparing the specific gravity of potatoes from delayed harvests in the spring and fall at Baton Rouge indicates the influence of temperature on dry matter content. Delaying the spring harvest, while the temperature increased, resulted in a lower specific gravity of the tubers. Those from the fall crop, however, were of higher specific gravity as harvest was delayed and temperature decreased.

Lack of statistical significance between mealiness ratings and some tuber constituents further emphasizes the need for a more objective method of quality evaluation. Variance in mealiness ratings of tubers having the same specific gravity, starch, and dry-matter content seems, principally to be due to the subjective nature of the taste-panel method of quality evaluation.

A further discrepancy in the use of specific gravity-mealiness associations as tuber quality criteria is shown by a comparison of these factors in potatoes grown at Wisconsin during 1957 and 1958. Samples from the 1957 crop were rated higher in mealiness than those grown during 1958, whereas the specific gravity of tubers from each variety in 1957 was lower than that of the 1958 crop. However, the higher mealiness rankings of the tubers from the 1957 crop may be explained by their higher amylose content (Figs. 1 and 2). There was a significant relationship between mealiness ratings and the per cent amylose in these potatoes ($r = .958$).

Mealiness scores and amylose content of potatoes produced in Wisconsin during 1957 averaged highest of all crops, whereas those grown at Baton Rouge in the spring of 1957 were lowest in both respects. Russet Burbank tubers at both locations consistently ranked highest in mealiness and per cent amylose, although the reverse was generally true of Red LaSoda potatoes. This would seem to indicate that the amylose content had some influence on mealiness evaluations of the taste panel. Ratings of the tubers of all varieties in these factors, averaged over all crop seasons and locations, show that a correlation did exist.

The decrease in amylose content of Louisiana spring-grown tubers, and increased amount in those from the fall crop there, as harvest was delayed, follows similar patterns in mealiness ratings and starch content. Apparently, increasing respiration rates and temperatures caused a decrease in the amount of amylose in the spring-grown tubers, whereas cooler fall temperatures were responsible for increasing amylose in tubers. Lower mealiness ratings of potatoes as spring harvest was delayed and the higher scores of samples from delayed fall harvests show that the per cent amylose in the tubers had some influence on taste panel ratings.

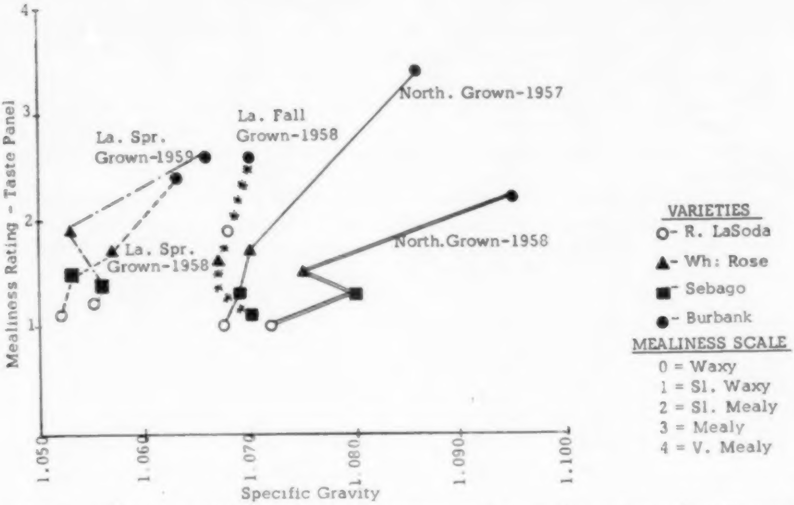

Figure 2. Effect of varieties, location, and season on the specific gravity and mealiness of potato tubers.

The significance between the percentage of amylose and most other factors in tubers grown under all conditions of this study suggests that an amylose analysis would be a more objective method of culinary quality rating than specific gravity or taste panels. Although the work reported here was necessarily limited to four potato varieties, amylose determinations and quality comparisons were made with tubers of many other varieties and seedlings. Associations found between per cent amylose and starch content, mealiness scores, specific gravity, and dry matter percentage of these potatoes were similar to those reported herein. The amylose test used was simple and rapid, requiring only a small sample. Agreement of results with other methods was good, and the amylose test affords quick comparison of a large number of tuber samples.

Per cent total starch in tubers from the delayed spring and fall harvests followed a trend similar to that of amylose and specific gravity. Starch content decreased in the spring and increased during the fall at Baton Rouge. Since there was a high degree of correlation between the amylose and total starch content of the tubers, this similarity seemed logical. It has been reported that a significant relationship existed between mealiness ratings and per cent starch in the tubers (2, 14, 19). However, some workers (19) have pointed out that mealiness scores could not be explained by starch content alone. Potatoes having a low mealiness rating also contained less amylose than those with a high mealiness rating.

Environmental and varietal differences seemed to affect the total starch and amylose content of tubers. Potatoes of the same variety grown at both locations varied as much in per cent starch and amylose as those of different varieties at the same location. The influence of both these tuber constituents on mealiness ratings and specific gravity is shown by the

significant associations which existed between them. Total starch and amylose were correlated with taste scores and specific gravity of potato tubers. Potatoes of the four varieties also showed inherent differences in per cent starch and amylose. Russet Burbank tubers from Louisiana and Wisconsin consistently ranked highest. Red LaSoda, however, was lowest in total starch and amylose. Sebago and White Rose potatoes, of intermediate rating, maintained this relationship at both locations regardless of season.

Inherent varietal differences reported here indicate that the amylose content of tubers should be considered in a breeding program to improve the culinary quality of southern-grown Irish potatoes. Studies to determine the method of inheritance of high amylose content in tubers, and usage of parents possessing this quality, could result in progeny superior to present varieties in this respect. The use of the rapid amylose test in conjunction with a breeding program would be of value in allowing quick screening of seedling tubers for per cent amylose. An additional factor in favor of its use is that only a small sample is required.

Summary

Quality comparisons were made with tubers of Red La Soda, Sebago, White Rose, and Russet Burbank Irish potato varieties grown at a northern and a southern location.

Specific gravity and mealiness were significantly correlated in tubers grown at the southern location during the spring. Inherent varietal differences in specific gravity were found. Russet Burbank potatoes were highest, and Red LaSoda tubers lowest in specific gravity. Environment affected specific gravity. Tubers grown at the northern location were highest in specific gravity, those from the southern location in the spring lowest, and southern fall-grown potatoes were of intermediate ranking. The delay of spring harvest caused a lower specific gravity, although the reverse was true in the fall tubers.

There were significant relationships between mealiness ratings and the per cent amylose and total starch in potatoes. Amylose and total starch content were also highly correlated. Amylose content of Wisconsin and Louisiana fall-grown potatoes was highest, whereas Louisiana spring-grown tubers ranked lowest in this respect. Amylose content and mealiness of tubers decreased as harvest was delayed at the southern location during the spring, whereas the reverse occurred as fall harvests in Louisiana were delayed. Varietal, as well as environmental differences were found in amylose content and mealiness of potatoes. Russet Burbank tubers consistently ranked highest in these factors, and the Red LaSoda invariably rated lowest.

Amylose content of tubers appeared to be a more objective method of predicting quality than either specific gravity or taste panel methods.

Inherent varietal differences reported here also indicated that the amylose content of tubers should be considered in a breeding program to improve the culinary quality of southern-grown Irish potatoes. The amylose test could be used in conjunction with a breeding program, allowing rapid screening of progeny for amylose content.

Environmental and varietal differences also affected the total starch content of tubers. Potatoes grown at Baton Rouge in the fall ranked

highest in per cent total starch, those at this location in the spring lowest, and northern-grown tubers intermediate. The starch content of tubers decreased during successive harvests in Louisiana during the spring, although the delay of fall harvests there had the opposite effect. Inherent varietal differences in total starch content also existed. Russet Burbank tubers were consistently higher in starch and Red LaSoda tubers the lowest.

Literature Cited

1. Barmore, Mark A. 1937. Potato mealiness on cooking. Food Res. *2*: 377-384.
2. Bettelheim, F. A., and C. Sterling. 1955. Factors associated with potato texture. I. Specific gravity and starch content. Food Res. 20: 71-78.
3. Cobb, J. S. 1935. A study of culinary quality in white potatoes. Am. Potato J. 12: 335-347.
4. Haddock, J. L., and P. T. Blood. 1939. Variations in cooking quality of potatoes as influenced by varieties. Am. Potato J. 16: 126-133.
5. Halick, John V., and K. K. Keneaster. 1956. The use of a starch iodine-blue test as a quality indicator of white milled rice. Cer. Chem. 33: 315-319.
6. Hawkins, Arthur, *et al.* 1952. The relationship of specific gravity to mealiness as assessed by sensory methods. Am. Potato J. 29: 192-196.
7. Hotchkiss, A., *et al.* 1940. Cooking quality preferences for potatoes. Am. Potato J. 17: 253-261.
8. Kirkpatrick, M. E. 1951. Cooking quality, specific gravity, and reducing sugar content of early crop potatoes. U. S. Dept. Agr. Circ. 872.
9. McCready, R. M., and W. Z. Hassid. 1943. The separation and quantitative estimation of amylose and amylopectin in potato starch. J. Am. Chem. Soc. 65: 1154-1157.
10. Merchant, Charles H., and E. E. Gavett. 1957. Consumer acceptance of specific gravity separated potatoes. Maine Agr. Exp. Sta. Bull. 559.
11. Nielsen, J. P. 1943. Rapid determination of starch. Ind. Eng. Chem. (Anal. Ed.) 15: 176-179
12. Nielsen, J. P. 1945. Modifications of the rapid starch determination method. Ind. Eng. Chem. (Anal. Ed.) 17: 131.
13. Schark, A. E., *et al.* 1956. The influence of the specific gravity-mealiness relationship of potatoes. Am. Potato J. 33: 79-84.
14. Shewfelt, A. L.,*et. al* 1956. The relationship of mealiness in cooked potatoes to certain microscopic observations of the raw and cooked products. Can. J. Agr. Sci. 35: 513-517.
15. Smith, Ora. 1950. Using the potato hydrometer in choosing potatoes for chipping. Nat'l Pot. Chip. Inst., Art. 10:1-12.
16. Sterling, C., and F. A. Bettelheim. 1955. Factors associated with potato texture. III. Physical attributes and general conclusions. Food Res. 20: 130-137.
17. Stevenson, F. J., and F. Whitman. 1935. Cooking quality of certain potato varieties as influenced by environment. Am. Potato J. 12: 41-48.
18. Sweetman, M. D. 1936. Factors affecting the cooking quality of potatoes. Maine Ag. Exp. Sta. Bull. 383: 297-378.
19. Unrau, A. M.., and R. E. Nylund. 1957. The relation of physical properties and chemical composition to mealiness in the potato. II. Chemical composition. Am. Potato J. 34: 303-312.
20. Whittenberger, R. T. 1951. Changes in specific gravity, starch content, and sloughing of potatoes during storage. Am. Potato J. 28: 738-747.

HYPERSENSITIVITY TO VIRUSES A AND X IN CANADIAN AND AMERICAN POTATO VARIETIES[1]

R. H. BAGNALL[2]

Certain potato varieties are known to be "hypersensitive," "intolerant" or "necrotic" in their reactions to one or more viruses. The condition is specific between the variety and the virus, or in some cases a particular strain of the virus. It has been correlated with field resistance to potato viruses A (12, 22), F (2), X (4, 12) and Y (3, 27) (also virus C or Y^c) (12). The form of necrotic reaction and the degree of resistance differs considerably with respect to the different viruses — and there are some differences between the necrotic reactions of different varieties to the same virus. However, the hypersensitive-type of resistance to viruses A and X, the subject of this paper, is so effective under natural conditions that varieties concerned have often been termed "field immune" (11). Varieties that are hypersensitive to these two viruses react with "top necrosis" (25) when infected with the specific virus by graft inoculation.

The reaction of varieties to virus A and to two strains of virus X — commonly referred to as "virus X" and "virus B" — is governed in each case by a single allelic pair of genes, dominant for the necrotic response. The dominants have been termed N_a, N_x, and N_b respectively, and the recessives n_a, n_x, and n_b (7, 13, 14). Moreover, breeding for resistance has been found to be practical (6, 34).

A knowledge of the reactions of different varieties is of value to the pathologist, inspector, seed-grower, and breeder. In Britain and Europe, where studies relating to hypersensitivity were closely linked with the work of separating and distinguishing the complex group of viruses involved, surveys of varietal reactions have been made (4, 12, 22, 26, 28, 29). The "streak" of Schultz (31) appears, actually, to be the first description of top necrosis. But, its significance was overlooked at the time and American workers meanwhile found other types of resistance to viruses A and X (next paragraph). Consequently, their references to hypersensitivity have been brief and scattered (1, 12, 21). Available Canadian and American varieties and some American seedlings of interest to breeders were therefore tested. For comparative purposes, some British and European varieties were included.

There are other types of resistance to viruses A and X not associated with these hypersensitive reactions (34). Katahdin and a number of related varieties, though susceptible and non-necrotic when inoculated by grafting, are virtually immune to aphid-induced infections with virus A. This, too, has been termed "field immunity." The U.S.D.A. Seedling 41956 and its progeny Saco and Tawa are considered immune to all known strains of virus X. The virus-X-immunity interferred with my tests to determine possible presence of the N_x and N_b genes, but otherwise neither this nor the Katahdin-type resistance to virus A are considered in this paper.

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Materials, Methods and Results

The viruses used are described below:

Virus A

The source of this virus was a "mild mosaic" diseased Green Mountain plant, supplied by Dr. D. J. MacLeod of Fredericton, N. B., the stock having been obtained originally from E. S. Schultz (36). The virus was transferred to a plant of U.S.D.A. Seedling 41956 — immune to virus X — and maintained in progeny of this plant. Reactions to this isolate of virus A by different potato varieties and other indicator hosts conformed to Murphy and McKays' (22) original description of virus A.

Virus X

This is the "healthy potato virus" of Johnson (18) but the popular name is derived from Smith's (33) use of the algebraic symbol X to distinguish it from another virus Y. With respect to hypersensitivity in potatoes, we must consider several strains of virus X. These differ in their ability to invoke the N_x and N_b genes. This method of classifying strains is distinct from classifications based on "virulence" (20, 30) — and each of the strains described below could probably be further broken up into "mild" and "severe" or "mottle" and "ring-spot" types. Cockerham (13) has previously classified these strains of virus X in similar groups[3] — but for the convenience of the reader, I am identifying the strain group with the respective necrotic genes that they will invoke.

Virus X^x: This is the strain designated "virus X" by Bawden (4). It incites top necrosis in varieties such as Epicure (N_xn_b), but not in varieties like Arran Victory or Katahdin (n_xN_b). This strain can be found in many varieties of n_xN_b constitution. My source was a naturally infected line of Katahdin. It was a comparatively "mild" type of the virus, inciting no noticeable symptoms in Katahdin and predominantly a mottling when transferred by sap inoculation to the common indicator hosts, *Datura tatula* L. and *Nicotiana tabacum* L. (var. White Burley).

Virus X^b: This is the "pure virus B" of Scott (32) that incites top necrosis in Arran Victory but not in Epicure. It was shown, actually, to be related to virus X (10, 12). Viruses X^x and X^b differ, so far as I could observe, only with respect to the hypersensitive reaction in potato. No significant differences have been shown between them physically, serologically, or in reactions or differential host plants. They are therefore considered strains of the same virus. Virus X^b is apparently rare in nature, for no potato of N_xn_b constitution has ever been found naturally infected — Scott having encountered it in plants of Duke of York (n_xn_b). My source of virus X^b was a line of King Edward obtained recently from Dr. D. Grovier, Pentlandfield, Scotland. It was actually used here to test only a few varieties, but these included all of N_x constitution. The virus was quite "mild" on *D. tatula* and *N. tabacum*.

[3]My virus X^x corresponds with Cockerham's Group III; X^b with his Group II, X^{xb} with his Group I. He had also in Group IV, a virus of Bawden and Sheffield (5) that did not incite top necrosis in any variety—which would be X^o by my classification.

Virus X^{xb}: This was the original virus B of Bawden (4), who found it to incite top necrosis in both Epicure and Arran Victory. He took this to be a mixture of virus X and another virus that he named "virus B." He could not, however, isolate the virus B from the mixture. Others apparently could not, either — I have not been able to do so — and Cockerham (13) has advanced the argument that this supposed "mixture" is really not such a mixture but a single strain of virus X, able to invoke either of the N_x or N_b genes. But, mixture or not, a virus of this type from a line of Irish Cobbler served, here, to test for the N_b gene in all but a few of the varieties. It was necessary to use virus X^b to test varieties of N_x constitution. My virus X^{xb}, too, was comparatively "mild" in its differential host reactions.

Plants of each potato variety or seedling being tested were top-grafted with potato scions bearing, one of the viruses A, X^x, X^b, or X^{xb}. The top 1 or 2 inches was cut off a 4 to 8 inch test plant, several of the uppermost remaining leaves trimmed away, and the stem slit lengthwise for 1 to 2 inches. The scion — a 2 to 4 inch shoot from a virus source plant, its base cut wedge-shape — was inserted into the slit and bound in place with rubber ribbon. The test plant soon developed side shoots and on these and later in sectioned tubers, the reaction was observed. Top necrosis (Fig. 1) or tuber necrosis (Fig. 2) indicated that the test plant carried the N_a, N_x, or N_b gene as the case might be. Where no clear necrotic reaction developed in the test plant, an attempt was made to recover the particular virus so as to ascertain that the test plant was actually infected. Virus A was identified in varieties of n_xn_b constitution — likely to carry virus X^{xb} — by grafting scions from them to virus-X^{xb}-tolerant Irish Cobbler ($N_an_xn_b$); and in n_xN_b varieties — whose scions would be killed by virus X^{xb} from Irish Cobbler — by grafting to Canso ($N_an_xN_b$). There was no occasion to test a variety of N_x constitution for virus A. The virus X^x, X^b, and X^{xb} strains were identified by grafts to Epicure and Katahdin. Non-necrotic reaction to infection indicated that the variety being tested carried the n_a, n_x, or n_b gene. The results are given in Table 1.

Discussion

Where possible (8, 16, 17, 19, 23, 35, 37, 38) I have obtained the pedigrees of the American and Canadian varieties. North American varieties carrying the N_a gene can, with few exceptions, be traced back to Garnet Chili, mostly through Earlaine, Irish Cobbler and Early Rose. Exceptions are Calrose, which evidently inherited the character from the Dutch variety Ackersegen; and two older varieties, Spaulding Rose and Early Pinkeye whose origin is not definitely known, but from appearances, are likely related to Early Rose. Early Rose was used extensively in European breeding, but I have not attempted to trace its influence there. Presence of the N_a gene provides circumstantial evidence — early needed by historians (8, 35) — of relationships between some of the older varieties.

No North American variety carried the N_x gene. This is not surprising, for only Canoga (n_x) had a parent (Albion) that did so.

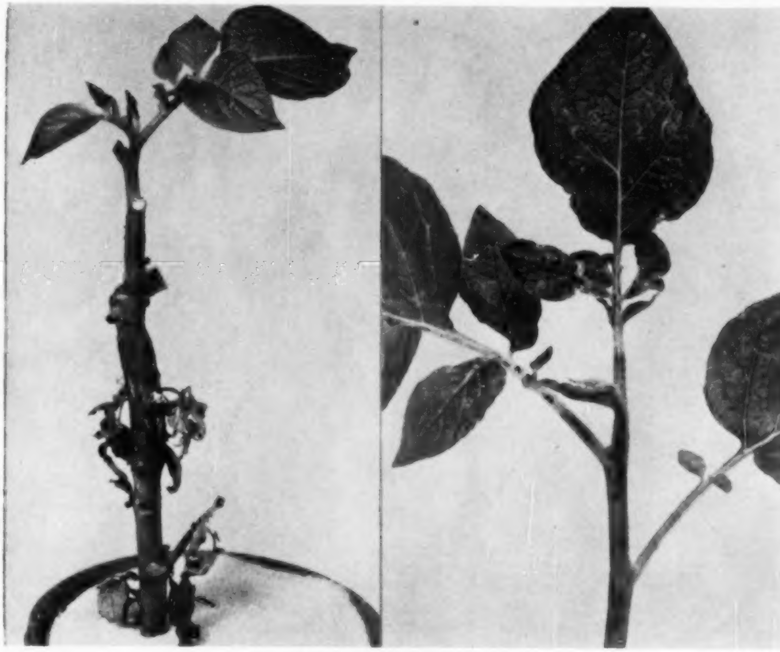

FIG. 1.—Top necrosis—external appearance.

Left: Reaction of hypersensitive variety (Katahdin) to virus X^{xb} from Irish Cobbler scion.

Right: Shoot of Kerr's Pink showing reaction to virus A. Note localized lesions showing internally.

The newer North American varieties that carry the N_b gene appear mostly to have inherited this through Katahdin or one of its parents. Of the grandparents of Katahdin (9), I have tested three, (Rural New Yorker, Aroostook Wonder (American Giant), and Flourball) and found them to carry only the n_b gene. The source of the N_b gene seems, therefore, to be the fourth — the Polish variety Busola. Besides Busola, four other European varieties that carry the N_b gene, Ackersegen, Hindenburg, Jubel, and President appear in the parentage of some newer North American varieties. In three varieties, Canus, Essex, and Keswick, however, I cannot account directly for the presence of the N_b gene. The N_b gene occurs in only two of the older North American varieties, McIntyre and Never Rot, but these actually may be seedlings or synonyms of British varieties.

I found the top necrosis reaction much as described by Quanjer (24). In affected shoots the necrosis usually originated in strands of the internal phloem and spread into the nearby parenchyna (Fig. 3—upper). The lesions were soon surrounded by a cork cambium (Fig. 3—lower), except

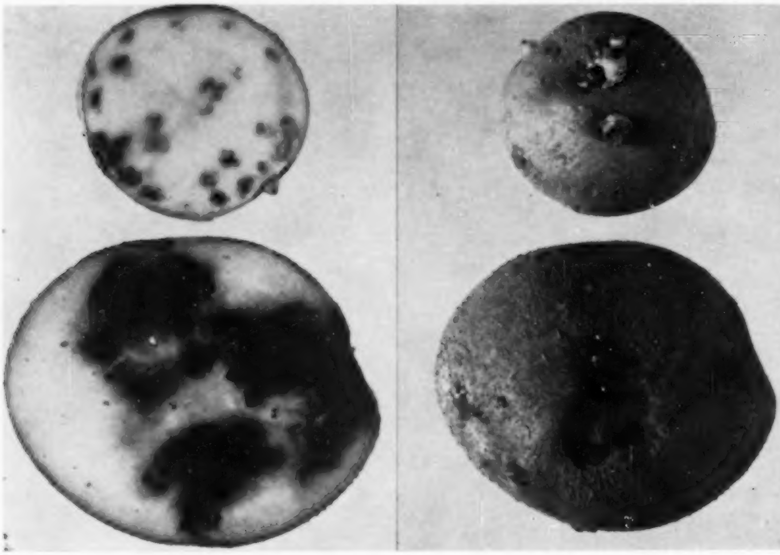

FIG. 2.—Tuber necrosis (virus A).
Upper left: Localized type in Saco.
Lower left: Extensive necrosis in Seedling B606-37.
Right: External view of the same tubers.

in the tender tips of the shoots which were rapidly destroyed. Externally a necrotic spotting appeared on the uppermost leaves, followed by a dying of the shoot from the top downward (Fig. 1). Necrosis also occurred in the tubers, sometimes in the form of a few small internal lesions, but at others quite extensively, perhaps involving one or more eyes (Fig. 2).

The necrotic response to virus A was usually slow to appear, taking 20 to 30 days, and it seldom killed the entire shoot (Fig. 1—right). It was limited in some varieties to the apical bud, and under unfavorable environment — high temperatures of mid-summer and low light intensity of mid-winter — was sometimes completely inhibited. Tuber necrosis almost invariably occurred, however, — usually after several months in storage at either 4° or 20C. — and sometimes indicated hypersensitivity where no "top necrosis" was seen.

The necrosis in response to viruses X^x and X^{xb} was more rapid, appearing in 10 to 20 days, and usually destroyed the shoots (Fig. 1—left). It appeared to be less affected by environment than the virus A reaction, although it — like the latter — was best observed in our greenhouses during the late winter and early spring and for a shorter period in early fall. The virus X^x or X^{xb} reaction sometimes destroyed the test plant before tubers were formed, or destroyed the tubers in storage. Observations of the virus X^b reaction were few, but it seemed to be similar to the reactions to viruses X^x and X^{xb}.

TABLE 1.—*Constitution of different potato varieties with respect to the a, x, and b alleles for reaction to viruses A, X^x, and X^b.*

Variety	Origin	Source of tubers	Allelic series and phenotype		
			a	x	b
Ackersegen	Germany	LCY[3]	N[4]	n	N
Albion	Holland	DJM	N	N	n
Alpha	Holland	RWH	n	n	n
American Giant	Old US[1]	RVA	n	n	n
Antigo	US[2]	GHR	n	n	N
Arran Comrade	Britain	DJM	n	n	N
Arran Consul	Britain	DJM	n	n	n
Arran Pilot	Britain	DJM	N	n	N
Arran Victory	Britain	DJM	n	n	N
Ashworth	US	LCY	N	n	n
Avon	CDA[2]	LCY	N	n	N
Bintje	Holland	DJM	N	n	N
Bliss Triumph	Old US	DJM	n	n	n
Boone	US	RVA	N	n	N
British Queen	Britain	DJM	N	n	N
Calrose	US	RVA	N	n	N
Canoga	US	FJS	n	n	n
Canso	CDA	LCY	N	n	N
Canus	US	LCY	n	n	N
Cayuga	US	FJS	n	n	n
Champion	Britain	DJM	N	n	N
Cherokee	US	FJS	n	n	N
Chippewa	US	DJM	n	n	N
Chisago	US	FJS	n	n	n
Craigs Defiance	Britain	DJM	N	N	N
Dakota Chief	US	RVA	n	n	N
Dazoc	US	RVA	n	n	n
Delus	US	LCY	N	n	n
De Sota	US	FJS	n	n	N
Earlaine	US	LCY	N	n	n
Early Gem	US	RHL	n	n	n
Early Ohio	Old US	DJM	n	n	n
Early Pinkeye	US	DJM	N	n	n
Early Rose	US	RWH	N	n	n
Eigenheimer	Holland	LCY	n	n	n
Empire	US	DR	n	n	n
Epicure	Britain	DJM	N	N	n
Erdgold	Germany	LCY	n	n	N
Erie	US	RVA	N	n	N
Essex	US	LCY	n	n	N
Fauna	Holland	LCY	n	n	n
Fillmore	US	FJS	n	n	n
Flourball	Britain	DJM	n	n	n
Fortuna	Germany	RWH	N	N	n
Fundy	CDA	LCY	N	n	N
Garnet Chili	Old US	AES	N	n	n
Golden	US	LCY	n	n	n
Green Mountain	Old US	DJM	n	n	n
Hindenburg	Germany	LCY	N	n	N
Houma	US	DJM	n	n	n
Imperial	Sweden	DJM	n	n	n
Irish Cobbler	US	DJM	N	n	n
Irish Daisy	US	DJM	N	n	n
Jubel	Germany	LCY	n	n	N
Kasota	US	LCY	n	n	n

TABLE 1.—(*Continued*)

Katahdin	US	DJM	n	n	N
Kennebec	US	LCY	n	n	n
Kerr's Pink	Britain	RHL	N	n	N
Keswick	CDA	LCY	n	n	N
Knick	US	RVA	n	n	n
LaSalle	US	FJS	n	n	N
LaSoda	US	FJS	n	n	n
Majestic	Britain	DJM	n	n	n
Manota	US	LCY	n	n	n
Marygold	US	LCY	n	n	n
McIntyre	Old Can.[1]	DJM	n	n	N
Menominee	US	FJS	n	n	N
Merrimack	US	LCY	N	n	n
Mesaba	US	LCY	N	n	n
Mohawk	US	LCY	n	n	n
Netted Gem	Old US	LCY	n	n	n
Never Rot	Old Can	DJM	n	n	N
Noördeling	Holland	LCY	n	n	N
Nordak	US	LCY	n	n	n
Norgleam	US	LCY	n	n	n
Norkota	US	LCY	n	n	N
Norland	US	LCY	N	n	N
Onaway	US	CEP	n	n	N
Ontario	US	FJS	n	n	n
Osage	US	RVA	n	n	N
Osseo	US	FAK	n	n	N
Pawnee	US	LCY	n	n	n
Placid	Cornell	DR	n	n	n
Plymouth	US	LCY	n	n	n
Potomac	US	LCY	n	n	n
Pontiac	US	LCY	n	n	N
President	Britain	DJM	n	n	N
Progress	US	FJS	N	n	n
Pungo	US	FJS	N	n	N
Record	Holland	LCY	N	n	N
Redbake	US	WT	N	n	n
Red Beauty	US	GHR	n	n	n
Redglo	US	WT	N	n	
Redkote	US	RVA	n	n	N
Red McClure	Old US	LCY	N	n	n
Red Warba	US	LCY	n	n	n
Rural New Yorker	Old US	RVA	n	n	n
Rushmore	US	MR.	n	n	n
Russet Burbank	Old US	LCY	n	n	n
Russet Rural	Old US	LCY	n	n	n
Saco	US	RHL	N	I	I
Saranac	US	FJS	n	n	n
Satapa	US	FJS	N	n	N
Sebago	US	DJM	n	n	N
Seneca	US	FJS	N	n	N
Sequoia	US	LCY	n	n	N
Sheridan	US	RVA	N	n	n
Snowdrift	US	FJS	n	n	N
Southesk	Britain	DJM	N	N	n
Spaulding Rose	Old US	LCY	N	n	n
Tawa	US	LCY	N	I	I
Teton	US	DJM	N	n	N
Up-to-Date	Britain	DJM	N	n	n
Voran	Germany	LCY	n	n	N
Virgil	US	DR.	n	n	n

TABLE 1.—(*Continued*)

Warba	US	DJM	n	n	n
Waseca	US	FJS	n	n	n
White Cloud	US	FJS	n	n	N
White Rose	Old US	LCY	n	n	n
Yampa	US	FJS	N	n	N
Seedling B96-56	US	LCY	N	n	n
Seedling X927-3	US	RHL	n	n	N
Seedling 41956	US	DJM	n	I	I
Seedling B606-37	US	FJS	N	I	I

[1]Older U. S. or Canadian Varieties.
[2]Newer varieties released through U. S. state, federal or cooperative state-federal breeding programs since 1932, or by the Canada Department of Agriculture since 1950.
[3]Initials refer to: R. V. Akeley, Beltsville, Md.; R. W. Hougas, Madison, Wis.; F. A. Krantz, St. Paul, Minn.; R. H. Larson, Madison, Wis.; D. J. MacLeod, Fredericton, N. B.; C. E. Peterson, East Lansing, Mich.; D. Reddick, Ithaca, N. Y..; G. H. Rieman, Madison, Wis.; M. Rominsky, Rheinlander, Wis.; A. E. Schark, Presque Isle, Me.; F. J. Stevenson, Beltsville, Md.; W. Trank, Alliance, Neb.; J. C. Young, Fredericton, N. B.
[4]N = necrotic; n = non-necrotic (susceptible); I = immune (presence of N or n gene indeterminate).

I have noted previously (2), the reactions to different viruses, that extreme localization of the necrosis seemed to be correlated with greater relative resistance — whereas more extensive necrosis denoted lesser resistance. Experience in the present work agrees with this. Although field resistance to all three viruses bordered on immunity, the relative resistance to virus A was seen in several ways to be the greater. Varieties hypersensitive to virus A could not be infected by sap inoculation, whereas those hypersensitive to virus X^x or virus X^{xb} could often be infected systemically in this way, with resultant top necrosis. Also, when tubers were saved and sprouted following top necrosis in the mother plant, caused by virus X^x or virus X^{xb}, I observed a few cases where the secondary plants, too, developed top-necrosis. I have, in fact, found several plants of Epicure (N_x) — all severely necrotic and all progeny of one tuber — naturally infected with virus X^x but, progeny of plants that had top necrosis caused by virus A were invariably healthy. There were also differences noted in the hypersensitive reactions of different varieties to the same virus. In some, the necrosis was more extensive than in others. Cockerham and M'Ghee (15) have suggested that secondary resistance factors operate in both the hypersensitive and non-hypersensitive varieties — and that in the former these determine the ability of the variety to localize the virus and, hence, the necrosis. Evidence of localization can be seen in Fig. 3, where the necrotic tissues have been walled off by cork tissue.

Since the collection of different varieties used in this work came from diverse sources, an alert was maintained for any contaminant viruses that might have interfered with the simple testing procedure. Many of the varieties were infected with potato viruses S and X, and in addition, virus A was found in the Golden Wonder, virus F in Albion, virus M in Champion, Fortuna, King Edward, and in some Katahdin, Keswick, and Saco, and virus Y^c in Thorbecke. None of these infected varieties showed

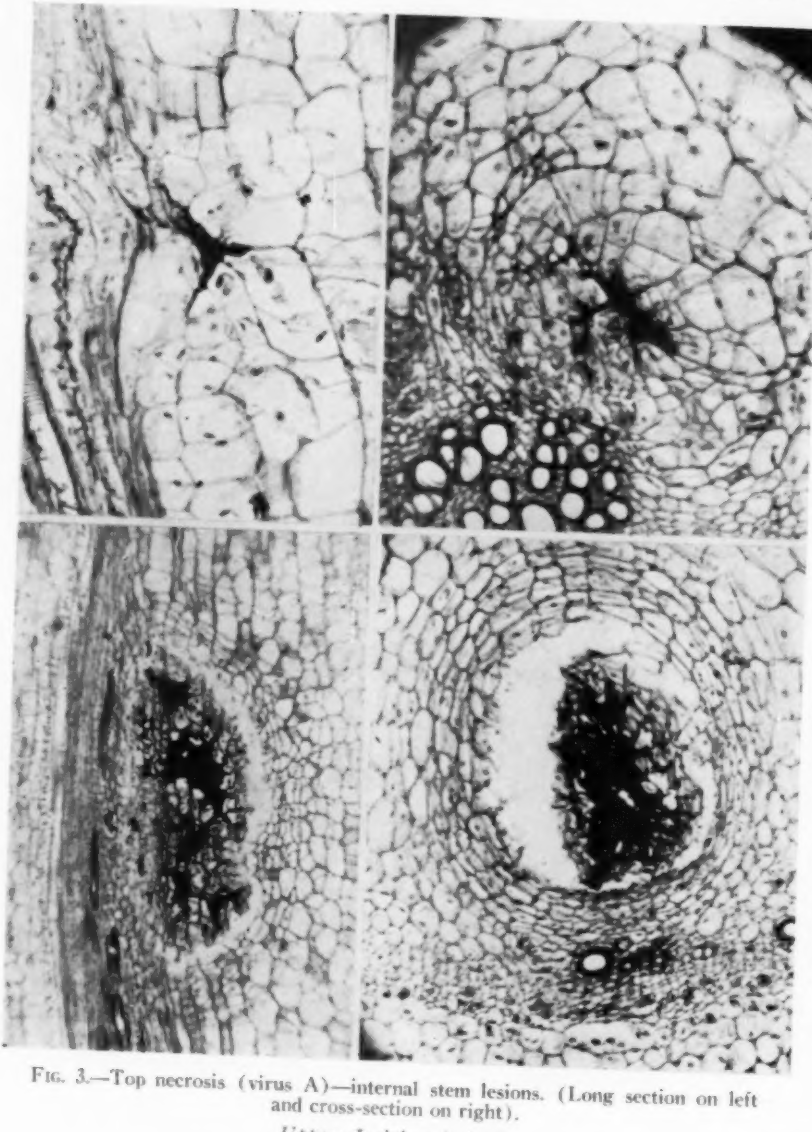

FIG. 3.—Top necrosis (virus A)—internal stem lesions. (Long section on left and cross-section on right).

Upper: Incipient lesions.

Lower: Late stage showing cork formation.

conspicuous symptoms. There was no evidence that any of these contaminant viruses affected my results, but the 9 "carriers" named above had one interesting factor in common. They were either resistant to virus X, or had been systematically kept free from it; the latent virus X seemingly being exchanged in each case for another latent virus. Evidently resistance in potatoes to one or even several viruses is not enough, and if breeding for such resistance is justified, it will tend to become more and more complex.

Literature Cited

1. Bagnall, R. H. 1949. Varietal resistance and immunity of potatoes toward certain viruses. M. Sc. Thesis, McGill Univ., Montreal. 91 p.
2. Bagnall, R. H. 1960. Potato virus F latent in an imported variety and resistance to the virus in an interspecific potato hybrid. Phytopathol. 50: 460-464.
3. Bagnall, R. H., and R. H. E. Bradley. 1958. Resistance to virus Y in the potato. Phytopathology 48: 121-125.
4. Bawden, F. C. 1932. A study on the histological changes resulting from certain virus infections of the potato. Proc. Roy Soc. London, B., 61: 74-85.
5. Bawden, F. C. and Frances M. L. Sheffield. 1944. The relationship of some viruses causing necrotic diseases in the potato.. Ann. Appl. Biol. 31: 33-40.
6. Black, W. and J. C. Haigh. 1946. Potatoes: Breeding. Scot. Soc. Res. Plant Breed., Rept. (Abr.) Directors and Rept. Director of Res. Ann. Gen. Me.t. p. 12-17
7. Cadman, C. H. 1942. Autotetraploid inheritance in the potato: Some new evidence. J. Genetics 44: 33-52.
8. Clark, C. F. and P. M. Lombard. 1951. Descriptions of and key to American potato varieties. U. S. Dept. Agr. Circ. 741. 57 p.
9. Clark, C. F., W. Stuart, and F. J. Stevenson. 1933. The Katahdin and Chippewa potatoes. U. S. Dept. Agr. Circ. 276. 8 p.
10. Clinch, Phyllis M. 1942. The identity of the top-necrosis virus in Up-to-date potato. Sci. Proc. Roy Soc. Dublin (NS) 23: 18-34.
11. Clinch, Phyllis M., J. B. Loughnane, and P. A. Murphy. 1938. A study of the infiltration of viruses into seed potato stocks in the field. Sci. Proc. Roy. Soc. Dublin (NS) 22: 17-31.
12. Cockerham, G. 1943. The reaction of potato varieties to viruses X, A, B, and C. Ann. Appl. Biol. 30: 338-344.
13. Cockerham, G. 1955. Strains of potato virus X. Proc. 2nd Conf. Potato Virus Diseases. Lisse-Wageningen, 1954: 89-90.
14. Cockerham, G. and C. H. Cadman. 1942. Potatoes: virus diseases. Scot. Soc. Res. Plant Breed., Rept. (Abr.) Directors and Rept. Director of Res. Ann. Gen. Meet. p. 10-11.
15. Cockerham, G. and T. Marai R. M'Ghee. 1949. Potatoes: virus diseases. Scot. Soc. Res. Plant Breed., Rept. (Abr.) Directors and Rept. Director Res. Ann. Gen. Meet. p. 19-22.
16. Hougas, R. W., and R. W. Ross. 1956. The use of foreign introductions in breeding American potato varieties. Am. Potato J. 33: 328-339.
17. Johansen, R. H., N. Sandar, W. G. Hoyman, and E. P. Lana. 1959. Norland, a new red-skinned pootato variety with early maturity and moderate resistance to common scab. Am. Potato J. 36: 12-15.
18. Johnson, J. 1925. Transmission of viruses from apparently healthy potatoes. Wisconsin Agr. Expt. Sta. Res. Bull. 63, 12 p.
19. Johnston, G. R., H. T. Davies, and C. H. Lawrence. 1958. Huron, a new white, late maturing variety of potato resistant to common scab. Am. Potato J. 35: 715-720.
20. Ladeburg, R. C., R. H. Larson, and J. C. Walker. 1950. Origin, interrelation and properties of ringspot strains of virus X in American potato varieties. Wisconsin Univ. Agr. Expt. Sta. Res. Bull. 165, 47 p.
21. Mai, W. F. 1947. Virus X in the newer potato varieties and the transmission of this virus by the cutting knife. Am. Potato J. 24: 341-351.

22. Murphy, P. A., and R. McKay. 1932. The compound nature of crinkle and its production by means of a mixture of viruses. Sci. Proc. Roy. Soc. Dublin (NS) 20: 227-247.
23. Peterson, C. E., and W. J. Hooker. 1959. Tawa: A new early potato variety resistant to late blight, scab, and immune to latent mosaic. Am. Potato J. 36: 267-274.
24. Quanjer, H. M. 1931. The methods of classification of plant viruses, and an attempt to classify and name potato viruses. Phytopathology 21: 577-613.
25. Quanjer, H. M. and J. G. O. Botjes. 1929. Aardappelziekten van het 'stipplestreep' — en 'topnecrose' — type en het vroagstuk der latentic en physiologische specialisatie. Wageningen Lanbouwhoogesch. Meded. 33, 7, 44 p. (Abstr. in Rev. Appl. Mycol. 9: 481-483).
26. Ross, H. 1953. Uber die Resistenz der Kartoffelsorten gegen das A-Virus auf der Basis Uberempfindlichkeit. Z. Pflanzenziicht. 32: 153-156.
27. Ross, H. 1958. Inheritance of extreme resistance to virus Y in *Solanum stoloniferum* and its hybrids with *Solanum tuberosum*. Proc. Conf. Potato Virus Diseases III, Lisse-Wageningen, 1957.
28. Ross, H. and E. Köhler. 1951. Das Verhalten deutscher Kartoffelsorten gegenüber verscheidenen Stämmen des X-Virus im Pfropfversuch I. Zuchter 21: 179-185.
29. Ross, H. and E. Köhler. 1953. Das Verhalten deutscher Kartoffelsorten gegenüber verscheidenen Stämmen des X-Virus im Pfropfversuch II. Zuchter 23: 72-86.
30. Salaman, R. N. 1938. The potato virus 'X': its strains and reactions. Roy. Soc. (London), Philos. Trans., B, 229: 137-217.
31. Schultz, E. S. 1925. A potato necrosis resulting from cross-inoculation between apparently healthy plants. Science (NS) 62: 571-572, 1925.
32. Scott, R. J. 1938. Mosaic diseases of the potato. Scot. J. Agr. 21: 121-132.
33. Smith, K. M. 1931. Composite nature of certain potato viruses of the mosaic group. Nature 127: 852-853.
34. Stevenson, F. J., and R. V. Akeley. 1953. Control of potato diseases by disease resistance. Phytopathology 43: 245-253.
35. Stuart, W. 1923. The potato, its culture, uses, history and classification. Lippincott, Philadelphia. 518 p.
36. Webb, R. E. 1958. Schultz potato virus collection. Am. Potato J. 35: 615-619.
37. Young, L. C., and H. T. Davies. 1952. Potato breeding. Can. Dept. Agr., Expt, Farms Service, Dom. Expt. Sta., Fredericton, New Brunswick, Progress Rept. 1948-1952. p. 29-35.
38. Young, L. C., H. T. Davies, D. A. Young, and J. Munro. 1960. Fundy: A new smooth, early maturing variety of potato. Am. Potato J. 37: 274-277.

NEWS AND REVIEWS

RELATION OF CHLORO IPC FOR POTATO SPROUT INHIBITION TO INTERNAL SPROUTING OF POTATOES

R. L. Sawyer[1]

The potential of Chloro IPC for sprout inhibition of potatoes was discovered by Paul C. Marth of the U.S.D.A. Agricultural Research Service, Beltsville, Maryland. Marth and Schultz first published on this in 1952 and Heinze, Marth and Craft published on further tests in 1955.

Early work indicated the strong inhibiting potential using either a dust or a dip. Impregnated paper was not effective except for tubers close to the paper. In general, the conclusions of Marth and Heinze were that potatoes needed to be held at temperatures under 70 F immediately after treatment for a time to be effective; less rot was obtained with treated tubers at temperatures of 55 F or under, but more rot was obtained with treated tubers at 65 F.

Chloro IPC was found effective as a dip, a spray, or incorporated in a wax emulsion on potatoes by Heiligman and Wagner in 1957. Sprouting and weight loss were reduced at storage temperatures of 55 F, 72 F and 85 F and Chloro IPC seemed to have an indirect effect in controlling storage losses caused by microbial decay.

A new method of application was reported by Sawyer and Dallyn in 1956 and 1957. Chloro IPC gave effective inhibition when applied as a gas to potatoes in storage. Volatizing by heating to 200 C gave better results than atomizing into the ventilating air. However, both methods gave good commercial control. Application details consisted of a ventilating system delivering .25 cubic feet of air per bushel of tubers. After application, storages were kept closed and the air recirculated for 24 to 48 hours, followed by normal ventilating procedures. Chloro IPC was applied after adequate healing of cuts and bruises from the harvesting and storing operation.

Sawyer and Cetas in 1957 and 1958, working with 400-bushel experimental bins, found that Chloro IPC applied to well-cured potatoes in storage did not increase the amount of dry rot; however, the application to freshly harvested or poorly cured potatoes in storage could result in increased dry rot. Tubers treated with Chloro IPC and held at 50 F gave excellent control of shrinkage and black spot at a treatment dosage of ¼ gram per bushel.

Hendel in 1957 reported on several considerations in using Chloro IPC. Wound healing was greatly retarded by application of Chloro IPC to freshly cut surfaces and caused a loss of fluid and blackening of the surfaces; and air velocity was important in storage for uniform distribution. Hendel also found Chloro IPC to have a fungistatic effect on dry rot organisms. Sprouting of potatoes was effectively controlled at 50 F with 1 to 2 ppm on the tubers.

[1]Cornell University, Riverhead, Long Island, New York.

Craft and Audia in 1959 felt that the low rate of penetration and translocation of Chloro IPC were related to the selectivity to inhibit sprouts without significantly modifying the metabolism of the intact tuber.

Julian Miller in both 1959 and 1960 found that Chloro IPC effectively controlled sprouting at 60 F for 4 months with a 1% dip or by storing untreated tubers in a cloth or paper bag impregnated with 1.0 gram of Chloro IPC. No effect on chipping color due to Chloro IPC was observed.

Sawyer and Cetas in both 1959 and 1960 found Chloro IPC to be very effective in controlling sprouting and shrinkage. No detrimental effects on chipping color or other storage disorders were observed from treatments in the 400-bushel experimental storage rooms.

In the 1959-1960 storage season, as soon as Pure Food and Drug Administration had given clearance for use of Chloro IPC in commercial storages, an experimental treatment program was established in storages across the United States to see under what storage conditions Chloro IPC could effectively control sprouting. Under this program, twenty-one treatments were made. An aerosol, using a mixture of Freon propellant and Chloro IPC, as well as a microsol using mechanical methods of propelling and droplet break-up were used. E. K. Plant of Pittsburgh Plate Glass Company, with R. L. Sawyer as a consultant on sabbatic from Cornell University, supervised these storage tests with the aid of State University Research and Extension personnel in the various areas. These State University personnel in most cases checked and reported on the degree of success of the treatments. Samples from each storage were analyzed for residues of Chloro IPC. Samples were also held at 70 F in a laboratory to study the effect on sprouting from each storage.

Approximately 150,000 cwt of potatoes were treated with Chloro IPC. Good through-ventilation was found necessary for adequate distribution with bulk stored potatoes. Good duct-spacing was necessary for adequate distribution with through ventilation. With pallet box storages, turbulant sources of air in aisles, and the use of boxes with slatted sides, in general, gave sufficient distribution of Chloro IPC. Envelope or shell cooling systems and bag storages did not allow adequate Chloro IPC distribution. The microsol appeared to give better results than the aerosol.

By letter or telephone, contact was made with storage managers at the end of the storage period to determine satisfaction and complaints. No mention in any case was made of internal sprouting. There were several storages where inadequate distribution gave poor sprout control. There was one case where a portion of the potatoes treated would not cure out. However, in that same area, several non-treated lots failed to cure out following similar storage time. In the storage involved with poor curing, only certain lots failed to cure out.

No association of Chloro IPC to internal sprouting had been reported in literature or were reported in the commercial trials up to the 1960-61 storage season. Potatoes had been treated in all stages of sprouting. In some of the commercial processing storages, lots were treated in a given storage with potatoes ranging from no sprouting at all to those having sprouts six inches long, and no internal sprouting was encountered at the end of the period.

Processors, prior to federal clearance, had tried Chloro IPC on large storage lots, some as early as 1957. These known processors ranged from the San Francisco area, Los Angeles, Central Colorado, the midwest, to the east coast. One large processing establishment with a research department has several years of unpublished data regarding Chloro IPC and had come across no association with internal sprouting. In all of these trials, only one processor had encountered some internal sprouting with Chloro IPC-treated potatoes in June 1957. However, this same processor in 1960, although no treatment was used, had to discontinue use of some potatoes in this storage because of internal sprouting. Potatoes were stored at 55 F with excessive air movement to prevent storage rots from spreading. This storage manager did not attribute the internal sprouting to Chloro IPC, but to the high storage temperatures which had developed in storage during the late spring months when his forced air proportioning system was not properly functioning in 1957.

As a result of this year's publicity on internal sprouting, another processor in Maine reported he had observed internal sprouting with two inhibitors last year as well as in untreated checks, and could not see any difference among treatments.

In the storage season 1960-61, Chloro IPC was made available as a microsol treatment applied as a service. In late January 1961, complaints of internal sprouting developed in Ohio and Pennsylvania. A survey of approximately a dozen storages in that area indicated the problem at that time to be mild in most cases, but severe in spots in others. All of these storages had been treated with Chloro IPC.

At this same time, a chipping plant on the east coast was visited which had two lines of non-treated potatoes running. Both Russet Rurals and Kennebecs were showing internal sprouting with the Kennebec being quite severe. A storage of Chloro IPC-treated potatoes being saved for later usage, showed no internal sprouting other than in three untreated pallets which had been removed during treatment as a check on the effectiveness of sprout control by Chloro IPC.

At the New York Potato School in Ithaca, on February 21, the problem of internal sprouting was discussed and the fact that it seemed to be associated with Chloro IPC-treated storages in the Ohio-Pennsylvania area brought out. After this meeting, several up-State New York growers found the problem when they returned from the school.

On Long Island, samples from treated storages were checked at the Long Island Vegetable Research Farm for sprout control by holding them at 70 F after treatment. With the previous research knowledge that a sufficient dosage of Chloro IPC gave permanent sprout inhibition, all storages which showed any marginal surface sprouting were immediately retreated. Only one case of internal sprouting occurred on Long Island. In this one case, two retreatments were made and internal sprouting was contained at the point where it was originally discovered in early February. Potatoes were processed from this treated storage to the processor's satisfaction, although increased help was necessary to pick out the chips showing internal sprouting. This same processor observed internal sprouting in this storage in 1960 although he used no inhibitor.

Internal sprouting of Chloro IPC-treated potatoes at the present time has occurred, to this author's knowledge, in some storages in Ohio, Penn-

sylvania, up-State New York, and Maine and one storage in Connecticut. In both Ohio and Pennsylvania, Chloro IPC-treated potatoes were still available from storages the first of February with no internal sprouting. Potatoes in one storage in the Red River Valley developed slight internal sprouting. However, the grower had a non-treated storage of similar potatoes with more internal sprouting than in the treated storage. In the Ohio-Pennsylvania area, where internal sprouting occurred, no untreated potatoes were available which had been held at similar storage temperatures. In some areas, maleic hydrazide-treated tubers had some internal sprouting, but less than Chloro IPC-treated tubers, at the same state of storage.

Certain general environmental conditions can be associated with internal sprouting in storages in all of the areas where Chloro IPC has been used. Storage temperatures have been 55 F and over, and most of them were in the 58 F to 62 F range. Continuous air movement is generally practiced to maintain this temperature through the pile with most storages using exhaust fans. This results in excessive shrinkage.

Internal sprouting in the past has been associated with potatoes which are old. Potatoes held at 40 F do not usually exhibit this phenomena until they are a year old. Processors storing at temperatures of 50 F or over frequently encounter the problem in the spring months. The problem of internal sprouting is frequently encountered in research samples held for long periods. Untreated potatoes are usually completely disintegrated by the time internal sprouting is encountered in treated produce.

After internal sprouting was encountered this spring, contact was made with various research men working with potatoes in the United States. One worker had observed the problem this past year with low dosage levels of Chloro IPC after 14 months' storage. One other worker had seen some internal sprouting on a cull pile where the research samples were dumped after a year old, but at that time could not tell whether the internal sprouting had come from Chloro IPC treatments or other treatments. Another worker said that he suspected that low levels of Chloro IPC might accentuate the problem. All of the other workers who have done considerable work with sprout inhibitors said they had never seen any association between Chloro IPC treatments and internal sprouting. This included the workers at Beltsville, Maryland, who originally discovered its potential.

As a reslt of this past season's phenomena, my personal feeling is that Chloro IPC at marginal dosages may accentuate the problem once potatoes are old. The aging of a potato can be accentuated by climatic conditions during the growing and storing period, and particularly by high storage temperatures and dehydration in storage. Attempts to make Chloro IPC and other inhibitors cause internal sprouting in storage research using this knowledge have been successful this year. Untreated tubers at the present time, stored at 50 F under refrigeration, have internal sprouting. Between one and two thousand 2-quart boxes of potatoes have been hand-desprouted annually for 7 years at the Research Farm and this is the first year internal sprouting has been encountered by March 1 following any treatment. Thousands of potatoes, held at 45 F to 55 F, in experimental bins receiving marginal dosage levels of Chloro IPC were cut and only one tuber had an internal sprout.

Certainly, before any further treatments are made in the areas that have the problem, a thorough investigation should be made of all factors and not just of Chloro IPC. Last summer, in the Red River Valley a sprout inhibitor other than Chloro IPC was temporarily considered the cause of internal sprouting until more knowledge of the causes of internal sprouting become known to those involved.

The satisfied growers are many. Those who have had a problem this year and have treated with Chloro IPC are very few in comparison with those who have treated and are completely satisfied. Requests for treatment this fall have already started to come in to the applicator on Long Island.

If Chloro IPC has accentuated the problem, the association is not clear cut. The State Extension Services, the research men and Pittsburgh Plate Glass went into this year's treatment with no knowledge of any association between Chloro IPC and internal sprouting. There is still no clear cut evidence that Chloro IPC is in itself the cause, but the evidence indicates an association under certain storage conditions which should be investigated before further treatment in the areas concerned.

Research is under way in several areas in an attempt to determine why internal sprouting was such a problem this past year, with and without the use of inhibitors. Many processors claim to have had the problem this past year for the first time. The general problem of internal sprouting is definitely not tied to any one inhibitor or sprout inhibitors in general.

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PROGRAM OF THE 45th ANNUAL MEETING OF THE POTATO ASSOCIATION OF AMERICA

In Conjunction With

THE NORTHWEST ASSOCIATION OF HORTICULTURISTS, ENTOMOLOGISTS AND PLANT PATHOLOGISTS

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July 25, 26, 27, 28, 1961

COLUMBIA HOTEL

Wenatchee, Washington

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TUESDAY, JULY 25, 1961 — 8:00 A.M.

Tour of the Potato areas in the Columbia Basin; the new research farm at Orthello, and new processing plant at Warden. Harvesting and shipping of potatoes will be in progress.

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REGISTRATION

Tuesday evening, July 25, 1961, and Wednesday morning, July 26, 1961, at the Columbia Hotel

WEDNESDAY MORNING, JULY 26, 1961

Columbia Hotel — 9:00 A.M.

ROBERT AKELEY, Presiding

1. **External and Internal (Blackspot) Mechanical Injury of Washington Russet Burbank Potatoes from Field to Terminal Market. (10 minutes).** FENTON E. LARSEN, Washington State University, Pullman, Wash.

2. **Potato Varieties and their Susceptibility to Blackspot when Bruised. (15 minutes).** R. KUNKEL, M. W. CARSTENS, W. G. HOYMAN and N. SANDAR, Washington State University, Pullman, Wash.

3. **A Possible Function of Potassium in Decreasing Susceptibility of Russet Burbank Potatoes to Blackspot when Bruised. (15 minutes).** R. KUNKEL, A. I. DOW, Washington State University, Pullman, Wash.

4. **Moisture Stress and the Development of Blackspot in Russet Burbank Potatoes when Bruised Following Root Pruning. (15 minutes).** R. KUNKEL and W. H. GARDNER, Washington State University, Pullman, Wash.

5. **Fertilizers and the Control of Blackspot in Washington. (15 minutes).** R. KUNKEL and A. I. DOW, Washington State University, Pullman, Wash.

6. **Graphic Analysis of Reducing Sugar Disappearance in Stored Potato Tubers. (15 minutes).** DONALD R. ISLEIB, Michigan State University, East Lansing, Mich.

7. **Chipping Tests of Several Potato Varieties and Selections Grown in North Dakota. (15 minutes).** R. H. JOHANSEN, North Dakota State University, Fargo, N. D.

8. **Some Pathological and Horticultural Characteristics of the Varieties Kennebec and Golden Chip. (15 minutes).** WILLIAM G. HOYMAN, Irrigation Experiment Station, Prosser, Wash.

9. **Breeding for Resistance to Diseases and Pests. (15 minutes).** C. M. DRIVER, Crop Research Division, Christchurch, New Zealand.

10. **A Program for Breeding Industrial Potato Varieties. (10 minutes).** G. V. HOUGHLAND, R. V. AKELEY and A. E. KEHR, Crops Research Division, Beltsville, Md.

11. **Germination of Solanum Pollen on Artificial Media. (10 minutes).** S. J. PELOQUIN, L. R. MORTENSON, and R. W. HOUGAS, University of Wisconsin, Madison, Wis.

WEDNESDAY AFTERNOON, JULY 26, 1961

Columbia Hotel — 1:30 P.M.

HUGH MURPHY, Presiding

1. **Effect of Levels of Phosphorus and Source of Nitrogen upon Potato Plant Growth, Leaf Tissue Composition, and Tuber Yield. (10 minutes).** HERMAN TIMM and JERRY RIEKELS, University of California, Davis, Calif.

2. **Nitrogen fertilization of the Katahdin, Saco and Plymouth Varieties in Maine. (15 minutes).** H. J. MURPHY and M. J. GOVEN, University of Maine, Orono, Maine.

3. **Effect of Planting Dates, Fertilization and Spacing on Yield, Storage Quality and Chipping Quality of Kennebec and Katahdin Varieties on Long Island. (15 minutes).** R. L. SAWYER, Cornell University, L. I. Vegetable Research Farm, Riverhead, N. Y.

4. **A Simplified Belt Attachment for Iron Age Potato Planters for Applying Small Quantities of Fertilizer. (5 minutes).** R. KUNKEL, Washington State University, Pullman, Wash.

5. **The W.S.U. Press Wheel Potato Planter. (15 minutes).** R. KUNKEL and N. SANDAR, Washington State University, Pullman, Wash.

6. **Simulated Hail Damage to Potatoes in Maine. (15 minutes).** H. J. MURPHY and M. J. GOVEN, University of Maine, Orono, Maine.

7. **Seed Potato Productivity After Cooling, Supercooling or Freezing. (15 minutes).** H. W. HRUSCHKA, R. V. AKELEY, A. H. SHARK, U.S.D.A., Beltsville, Md.; E. H. RALPH, University of Delaware, Georgetown, Del.; R. L. SAWYER, Cornell University, Riverhead, N. Y.

8. **Yield Variability Among Katahdin Seed Sources. (10 minutes).** R. L. SAWYER, Cornell University, Riverhead, N. Y.

9. **Weight Loss in Some Alaskan Potatoes Following Various Pre-Storage Treatments. (15 minutes).** CHARLES E. LOGSDON and HAROLD STEPHAN, Alaska Agricultural Experiment Station, Palmer, Alaska.

10. **New Applications of Fusarex to Stored Potatoes. (15 minutes).** J. K. KRUM, Sterwin Chemicals Inc., New York, N. Y.

11. **Further Work on the Alcohols for Sprout Inhibition. (10 minutes).** R. L. SAWYER, Cornell University, Riverhead, N. Y.

12. **Airflow and its Effect on Sprouting and Storage Losses of Russet Burbank Potatoes. (15 minutes).** WALTER C. SPARKS, University of Idaho Branch Experiment Station, Aberdeen, Idaho.

13. **"Stereo-Plotter" For Three-Dimensional Graphs. (15 minutes).** H. W. HRUSCHKA, U.S.D.A., Beltsville, Md.

THURSDAY MORNING, JULY 27, 1961

Columbia Hotel — 8:30 A.M.

ROBERT KUNKEL, Presiding

1. **A Comparison of Greenhouse and Field Grown Potato Plants in Regard to Late Blight Infection. (10 minutes).** KENNETH W. KNUTSON, University of Idaho Branch Experiment Station, Idaho, and CARL J. EIDE, University of Minnesota, St. Paul, Minn.

2. **Testing for Field Resistance to Potato Virus Y. (15 minutes).** A. P. BENSON and E. P. LANA, North Dakota Agricultural Experiment Station, Fargo, N. D.

3. **Effect of Host Resistance on Commercial Production of Virus X-Free Potatoes. (10 minutes).** A. P. BENSON and R. H. JOHANSEN, North Dakota Agricultural Experiment Station, Fargo, N. D.

4. **Transplants As a Source of the Green Peach Aphid, *Myzus Persicae* (Sulz) in the Potato Seed Producing Areas of Idaho. (15 minutes).** GUY W. BISHOP, University of Idaho, Aberdeen, Idaho.

5. **The Vitamin C Content of Raw Potatoes, Fresh Mashed Potatoes and Reconstituted Dehydrated Flakes. (15 minutes).** SHIRLEY V. BRING, CAROL GRASSL, JOYCE HOFSTRAND, University of Idaho, Moscow, Idaho; MILES WILLARD, Rogers Brothers Seed Co., Idaho Falls, Idaho.

6. **Observations on the Firming of Potato Tissue Slices on Soaking in Distilled Water. (15 minutes).** M. V. ZAEHRINGER, H. H. CUNNINGHAM, D. J. LETOURNEAU and J. T. HOFSTRAND, University of Idaho, Moscow, Idaho.

7. **Standardization and Refinement Studies of an Objective Cooking Method for Evaluating Texture of Potatoes. (15 minutes).** M. V. ZAEHRINGER, H. H. CUNNINGHAM, D. J. LETOURNEAU and J. T. HOFSTRAND, University of Idaho, Moscow, Idaho.

THURSDAY MORNING, JULY 27, 1961

Columbia Hotel — 10:15 A.M.

BUSINESS MEETING and COMMITTEE REPORTS

O. C. TURNQUIST, *President,* Presiding

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THURSDAY AFTERNOON, JULY 27, 1961

Columbia Hotel — 1:30 P.M.

ROUND TABLE DISCUSSION ON INTERNAL SPROUTING

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Columbia Hotel — 2:45 P.M.

BUSINESS MEETING

O. C. TURNQUIST, *President,* Presiding

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THURSDAY EVENING, JULY 27, 1961

Columbia Hotel — 6:30 P.M.

POTATO BANQUET

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FRIDAY, JULY 28, 1961

TOUR OF THE FRUIT AREAS

Time to be announced.

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